June 1967 Brief 67-10198

NASA TECH BRIEF

Glass Bead Shot Peening Retards Stress Corrosion Failure of Titanium Tanks

The problem:

The possibility of an incompatibility between titanium alloys and nitrogen tetroxide (N_2O_4) was suggested by the premature failure of rocket-propellant storage tanks during testing. These failures indicated stress corrosion resulting from the simultaneous corrosive action of N_2O_4 and mechanical stress. Since the compatibility of titanium alloys and N_2O_4 is considered vital to the fabrication of efficient rocket fuel systems, some method of overcoming the difficulty had to be devised.

The solution:

Subject the titanium tanks to rigidly controlled shot peening. The shot peening process sets up a residual compressive stress in the surface of a material that extends several thousandths of an inch below the surface. This compressive stress is accompanied by a tensile stress in the under fibers of the material. Since stress corrosion failures are usually the result of tensile stresses rather than compression stresses, the detrimental tensile stresses are materially reduced by the residual compression stress. The end result is the alleviation of stress corrosion failures through the addition of beneficial stresses.

How it's done:

Tests on small self-stressed titanium samples demonstrated the efficacy of shot peening with glass beads. These tests revealed that unpeened samples reached the threshold of stress corrosion damage when exposed to N_2O_4 at a temperature of 165° for 4 hours. By subjecting the test specimens to rigidly controlled shot peening with glass beads, the threshold of stress corrosion fatigue was materially extended.

Essentially, shot peening is a process whereby small particles are forcibly impelled against a surface. In this application the particles are glass beads, ranging in size from 0.0058 to 0.0097 inch in diameter. The glass beads are sprayed from a four-barreled nozzle held at the end of a rotatable nozzle arm. Each nozzle discharges about 0.25 million beads each second. The nozzle arm is positioned on the end of a lance arm to permit insertion into the tank. The lance arm is rotatable and a lance cart permits the linear positioning of the nozzle. The tank can also be rotated independently. Using combinations of these movements it is possible to program highly controlled coverage of the interior of the tank.

Notes:

1. Quality control is of vital importance in all shot peening, and this is especially true of the glass bead shot peening of titanium tanks. The primary quality control factors are:
   (1) The intensity of the blast
   (2) The angle of impact on the work
   (3) The degree of coverage
   In the glass bead shot-peening operation, the quality control factors are monitored on a 20-channel Brown recorder. Horn- and light-type warning systems monitor all programmed motions, the air supply, the bead flow, and the position of the nozzle covered.
2. A problem in measuring the glass bead flow was solved by monitoring the electrostatic charge built up around each of four lengths of Tygon tubing through which the beads flow.
3. The angle of impact and the degree of coverage is controlled by the tank rotation and the movement of the lance and the lance cart. The nozzle arm also has a mechanical drive that is variable between 0.001 and 0.020 radian per second.

(continued overleaf)

4. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Langley Research Center
   Langley Station
   Hampton, Virginia 23365
   Reference: B67-10198

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

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